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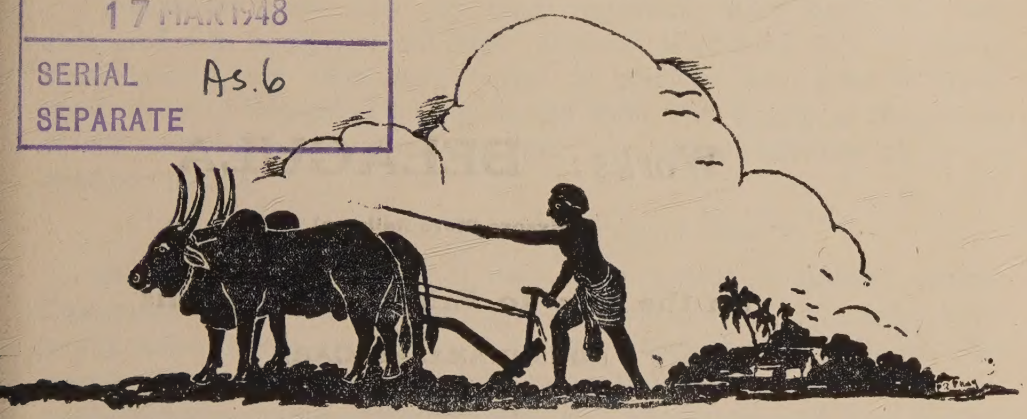

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The Mysore Agricultural Journal

(The Organ of the Mysore Agricultural and Experimental Union)

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Insects in Relation to Preservation of Food Grains*

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Insects, far more than any other organisms, have been intimately associated with foodgrains and other products of all kinds used for human consumption, ever since man began to produce and preserve them. Preservation of foodgrains is to be looked upon, very largely, as the process of safeguarding the material from the destructive activities of certain injurious insects.

1. Important Types of Storage Insects

Certain specialised forms of two main groups of insects, namely, Coleoptera, *e.g.*, beetles and weevils; and Lepidoptera, *e.g.*, moths—commonly infest cereals and pulses in storage—small as well as large. The cereals weevil, *Calandra oryzæ*; the pulses beetle—*Bruchus chinensis*; the paddy and wheat moth—*Sitotroga cerealella* ; and the rice and flour moth—*Corcyra cephalonica* — are the most widespread and destructive species confronting the process of preservation of foodgrains. Of secondary importance are two other beetles, *viz., Tribolium confusum* and *Rhizopertha dominica,* which are more partial to broken grains and milled products. The cereals weevil and the pulses beetle are much more harmful than the moths, since, they excavate, consume and defile the grains both in the adult and larval stages of their life; while the moths cause serious injury only in their larval or caterpillar stage.

2. Origin and Increase of Infestation

Although a small percentage of a few of these types of insects—especially the pulse beetle, affects the grains even during formation and hardening in the field, and thus form the initial source of infection of newly harvested stocks, the greater portion of insect infestation usually experienced in the stores, is the result of certain other contributory causes operating both

* Paper contributed to the Symposium on " Preservation and Processing of Food Grains " arranged under the auspices of the Society of Biological Chemists, India (Bangalore Branch) on 30th September 1945.

internally and externally to the grains stored. The moisture content of the grains is a very important factor and anything higher than 8–10% of moisture tends to render the harvested stocks extremely susceptible. When they are further stored, as often happens, in insect-ridden and defective receptacles, cellars or godowns with or without old and already infected material, the initial batch of insects, small or large as the case may be, multiplying very quickly, helps to increase the percentage of incidence correspondingly. Ill-ventilated and otherwise unsuitable storage places, further favour insect multiplication. Favourable physical factors such as high temperature and relative humidity operating externally in the storage godowns and outside also play a very important role in the rapid breeding of insects in stocks of grains. Moreover, the nature and methods of transport of freshly harvested or old grains and frequent delays in transit, when the materials may easily be exposed to all manner of uncontrolled factors, no less seriously affect their condition.

3. Nature of Damage and Extent of Loss

The grains forming not only the normal food of the insects but also the media in which they breed, are generally subjected to drastic excavation. In cases of severe infestation, the grains are even reduced to a state of powder with a very appreciable admixture of cast skins of the larvæ and empty pupal shells, as well as a number of dead and decaying bodies and a lot of excreta in the form of minute pellets. The respiratory and metabolic functions of the continually breeding population of insects tend to raise the internal temperature and cause the 'heating' of the grain; while the condensation of moisture inside the stores gradually create favourable conditions for the growth of mold and starting of fermentation. The cumulative effect of all this leaves the grains in a state varying from partial to almost complete destruction and defilement. Whatever quantities of grain might sometime have escaped the direct attention of the infesting insects, are also often rendered unsuitable for consumption because of serious contamination and appreciable loss of nutritive value. Reclamation and reconditioning of such stocks, even if possible, may not often be worth the effort and expense.

The total loss of stored grains due mainly to insect activities and other closely associated causes has been noted at a modest estimate, as about 3 million tons per annum in India. This is quite exclusive of the loss sustained by the cultivating classes in rural areas where a considerable amount of grains of all kinds meant for seed purposes is damaged and rendered unfit by insects. Wherever stocks of grain for purposes, either for seed or direct consumption, are left in the store undisturbed for periods longer than 3–6 months at a time, under unsatisfactory and defective conditions, there, insect activity and damage predominate and unless proper and adequate precautions are taken and periodical inspections and necessary measures carried out, huge losses become inevitable.

4. Indigenous Devices and Methods for Storage and Insect Control

A large variety of devices and methods are adopted in rural parts all over the country. They are especially applicable to comparatively small stocks of grains meant to serve the requirements of seed and food for the family, normally for a season or two, but rarely for a period of a few years. These devices and methods bear the stamp of traditional usage and are accepted by the village folk as the best without questioning their efficacy and are used by them year after year as a routine. A critical examination of these practices reveals that the majority of them is based on fairly sound principles ; but, unfortunately, in practical application, they lack seriously in exactitude and severely exclude the necessary attention to details, with the result that the advantages inherent in the methods are lost where their actual realisation is concerned. An unbiased survey of the indigenous devices and methods, as they are practised in rural areas, cannot but confirm the suspicion that most of them are of the nature of temporary palliatives rather than efficient preventives or reliable remedies. But it should be admitted that they are capable of being vastly improved, remodelled and readjusted without much expense, so as to render them far more beneficial.

Just a couple of simple and common practices of this kind may be mentioned here. Coarse or fine sand has been in general use for admixture with certain pulses. Investigation has proved that fine sand, as a top dressing, instead, for stocks of grains in bins and cellars, acts as an effective barrier. Not only does sand keep sound grains safe from Coleopterous insects, but it also helps to remove any original infection. The peculiar habits of pulse beetles, especially, have a close bearing on the effectiveness of this method. Then, the advantage of coating of pulses with moistened red earth, or the general admixture of the same material in a dry state or with the broken husk of paddy in a raw or scorched condition in use in villages, can easily be enhanced very markedly by the use of a small quantity of finely powdered siliceous earth or scorched or burnt paddy husk in intimate mixture with the grain. The abrasive and harmful action of the minute and hard particles of the fine dust, on the cuticle of the insect, it is, that gives the fine dust its superiority over the coarse and loosely sticking red earth or the husk.

5. Some New Developments and Other Possibilities in the Control of Store Insects

Inert Dusts.—An inert dust of vegetable origin has, for the first time, been recently developed in the Mysore Agricultural Department. Observations made by Mr. M. J. Narasimhan, Director of Agriculture in Mysore, of the methods of storing grains followed in the interior villages of the Malnad areas of the State, led to an investigation in the Entomological Laboratory of the value of burnt paddy-husk in the control of insects affecting different grains. Silica, of inert dusts, in general, responsible for the tearing down of the lipoid

layer of the cuticle of the insects and causing their death by the resulting desiccation, has, in this case, come to be derived from paddy-husk. This development in Mysore should be of special interest to the other rice-growing areas of India, as paddy-husk is easily available and plentiful, besides being extremely familiar to every one in rural as well as urban areas. It cannot be refuted that its familiarity to the population has an enormous psychological value in the event of an inert dust having to be used on a large scale in the preservation of foodgrains in periods of crisis. Any dust, foreign and generally unknown to the bulk of the consumers, in mixture with staple foodgrains may easily be looked upon with great suspicion.

Scorched or burnt paddy-husk ground to a fine state, has been found to be quite as efficient as the powders from quartz, felspar, corundum and other minerals in preserving sound grains from infection as well as in killing store insects of all kinds, when intimately mixed with dry grains at the rate of 1% of their total weight. Paddy-husk ash in view of its efficiency, easy availability, cheapness and its psychological value, bids fair to become a challenging competitor to the other known dusts and it cannot fail to interest the village folk, the trades people of different denominations as well as Government and other Agencies dealing with the preservation and storage needs of special emergencies of the kind now existing.

Mercury.—The general effectiveness of mercury against vermin under certain conditions has long been known in India ; but the exact nature and extent of the action of mercury on the insects of foodgrains and other products in storage was first worked out in the Mysore Entomological Department in the early part of this century. An exhaustive study of all the aspects of the action of the metal in a pure form and as amalgam is now being made here with a view to find out the possibilities of its usage under conditions of small and large storage of foodgrains. Because of the fact that the insecticidal action of mercury is confined to the egg stage of the life of insects of the store, it is to be looked upon as an extremely potent preventive agent and, any single initial preventive measure against infection and damage of foodgrains in storage, is easily worth half a dozen remedies instituted later when the pests have had a start or established themselves firmly. Mercury scores over the other chemical fumigants known; for, the latter are generally ineffective against the eggs of insects. Further, the use of mercury does not involve elaborate precautions necessary in the case of the known fumigants; above all, mercury of certain known weights corresponding to the volume of space or the bulk of the grain, is possible to be buried in small cloth or mesh-covered receptacles at different depths of the grain in bulk or in bags or bins and left there for almost the entire period of storage without any periodical scrutiny or other precautions. Any insects that may penetrate the grains, may just deposit their eggs; but the eggs fail to hatch because of the mercury vapour pervading the medium; mercury vapour actually penetrates the interior through the micropyle of the insect egg and

disintegrates and destroys the cytoplasm and nucleoplasm. Breeding is thus prevented and the parent insects themselves being short-lived, die out not long afterwards; the damage they might, perhaps, cause during the short period of their presence in the grain is negligible. Mercury thus appears to be much more suitable and advantageous for long-range storage of foodgrains. Germination and spectroscopic tests made in England on grain stored for several months with mercury gave no indication that contamination had resulted.

D.D.T.—Tests with this new and powerful insecticide against storage insects are in progress everywhere. It has not yet been definitely taken up for general use. The Director of Storage of the Central Government has planned an investigation and several workers all over India, including the Secretary of the Foodgrains Preservation Committee of Mysore, are now at it. Available results of tests made in U.S.A., with "technical D.D.T." indicate that this material is very effective when used undiluted, in intimate mixture with grains at very low concentrations of ·05% in a week's time and ·005% in a period of 2 weeks as in the case of inert dusts. D.D.T. being a powerful chemical insecticide has a special advantage over the common inert dusts, in that its poisonous action on the insects remains unaffected by higher moisture content of the grains treated, while, in the case of mineral and other inert dusts, a moisture content higher than about 12% seriously reduced the effectiveness of the dusts. D.D.T. is likely to be of value also as a general spray at 5-6% strength in odourless kerosene for the interior, floor, walls and ceiling of warehouses, godowns and even bins and transport vehicles of all kinds.

Biological control.—This is an aspect of storage-insects control, which has not been touched. Certain preliminary investigation has recently been carried out in the Entomological Laboratory here with reference to the possibilities of the utilization of certain known beneficial larval parasites of the pulse beetle—*Bruchus chinensis*, and the rice and flour moth—*Corcyra cephalonica*. The artificial multiplication of at least one of these parasites on a large scale in the Laboratory for releases to cover infected stocks of grain, is the problem confronting us at the moment. While it may not be difficult of solution, the fact that these parasites attack only half to full grown larvæ of the host insects should be considered to diminish their intrinsic value considerably. Because, by the time the larvæ develop to the stage preferred by their parasites, they would have had sufficient time to damage the grains. Unfortunately these and other insects of the store have practically no parasites worth serious consideration, attacking their eggs. Another limiting factor in the use of any beneficial parasite, larval or egg, in controlling the store insects, is its general incapacity to penetrate beneath the surface layer of grains or flour.

The very cosmopolitan egg-parasite, namely, *Trichogramma minutum*—which is a natural field parasite of the eggs of certain field insect pests—

such as the sugarcane stem-borer and which is now being mass-multiplied and released by us in millions in the sugarcane fields belonging to the Sugar Factory and the ryots in the Irwin Canal area of Mandya and Maddur has however been found to favour, freely, the eggs of the rice and flour moth and to some extent, those of the pulse beetle. This is certainly encouraging but the limiting factor mentioned before operates even here, though, to a lesser extent. This egg-parasite is essentially a parasite of completely exposed and uncovered hosts and as such, is not likely to respond satisfactorily to partially or entirely concealed hosts. Further studies with this and other parasites are continued. There is little doubt, however, that biological control, which is Nature's own method, if successful and practicable in the case of insects of foodgrains in storage, would, finally, be one of the best methods.

Finally, it may not be out of place here, to lay stress on the need for an adequate realisation of the urgent importance of comprehensive and efficient control of the insect enemy in rural and urban areas and under normal as well as emergent conditions. A tremendous lot of injurious insects affect all aspects of human activity and complacency and even underestimation where they are concerned, should, under no circumstances, be allowed to prevail.

Processing of Foodstuffs*

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The problem of nutrition in India is a fascinating one to the food economists. During wartime the question of sufficient calories is foremost in the field. But in normal times the question of sufficient calories takes care of itself. But aside from calories the question of protein is probably the first qualitative factor of importance. The average protein requirement is approximately 70 gm. *per capita* per day. In the application of modern nutrition practice it is recognised that protein quantity is not an adequate criterion of diet and that protein quality must also be taken into consideration. The value of proteins appears to depend upon their amino acid or so-called building stone content; ten such essential amino acids must normally be furnished by dietary proteins. Because of the differences in protein in this respect, the nutritive values of proteins vary widely.

Recent developments in the field of nutrition indicate that much could be done to improve the diets of a large percentage of our population without making changes which are either restrictive or unpleasant. From the studies which have recently taken place in respect to proteins, we are much better equipped to supplement the gaps in nutritional inadequacies by the use of simple foods from pusles, millets and contain oil-seeds. Much interest has recently developed in the nutritive value of plant proteins which may serve to partially replace proteins of animal origin, particularly those of meat, milk and eggs.

The need for developing this line of research is increasingly felt in countries like India where (*a*) the costly animal food at any rate, in sufficient quantity—is beyond the reach of the majority of the people ; and (*b*) a large section of the population is strictly vegetarian and will not take anything but purely vegetable food. Furthermore, with increasing population, the pressure on land is already so considerable that the land is required increasingly for producing grains and pulses required as human food rather than for maintaining farm animals. This inevitably necessitates increasing production of only purely vegetable food materials and to process them in such a way as to possess about the same ultimate food value as high class animal food.

It is now a recognised fact that food materials of vegetable origin possess ordinarily poorer nutritive value than those of animal origin. The latter are more easily digested and are often richer in essential amino acids,

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* Condensed from the paper contributed to the Symposium on " Preservation and Processing of Food Grains ", held under the auspices of the Society of Biological Chemists, India (Bangalore Branch), on 30th September 1945.

minerals and vitamins than the former. Even when vegetable materials are so blended that the composing units correspond to those of a useful animal diet, the results as measured by the extent of assimilation, growth response, resistance to disease, etc., are not the same. Even when experiments with rats and other animals give encouraging response, the same articles of food do not give equally good results when tried on human beings.

The reason for this fundamental discrepancy lies in the fact that vegetable food materials, even after cooking, are not so readily attacked by digestive juices secreted in the body as in the case of animal foods; that a large part of such food constituents are usually sent out undigested in the form of fæces; and also that the undigested food materials, if not properly eliminated are apt to undergo fermentation in the intestinal tract and cause a variety of secondary disorders. Practically all the lower animals have better digestive powers than man and are normally able to better utilise even raw course foods than man can. The tissue materials from the same animals are, in a way, concentrates obtained from the same coarse articles of food, so much so, that man who is in a position to kill and utilise the flesh of these animals gets food already prepared and stored for him in a concentrated and easily digestible form.

These facts are generally known and recognised in practice, though from the point of view of actual application, nutrition experts still prefer to go on the basis of ultimate composition since it is the only dependable criterion which they can employ and for the determination of which there are useful standards. A new practical approach is however badly needed with full recognition of the foregoing facts. Thus, it should be better realised that to get the best value of a food material—particularly one of vegetable origin —something more than mere cooking is necessary for better assimilation of the food constituents. If this can be achieved in practice, the strain on the digestive system will be greatly reduced and even comparatively coarse articles of food can be made to yield very valuable food constituents in a readily assimilable form.

Available Protein

Usually vegetable proteins have a lower nutritive value than that of animal proteins, *i.e.*, they have lower digestibility and biological value. If this factor is taken into consideration the protein available to us per acre of land is appreciably reduced. The following table illustrates this:

Source of protein	Average protein content in gm.	Digestibility	Digestible protein	Biological value	Available protein in gm.
	%				
Meat ..	20	95	19	95	18
Groundnut ..	25	80	20	50	10
Soya-bean ..	40	80	32	50	16
Pulses ..	20	80	16	55	8·8

This indicates that though in the case of meat more than 85 per cent. of the protein is available to us, in the case of pulses and oil-seed, rarely half of it is available.

Recent studies in the field of proteins indicate that by the application of different processing methods it is possible to increase the nutritive value of the proteins. The processes which help in increasing the nutritive value of the proteins are:

(*a*) cooking with or without the aid of chemicals;
(*b*) treatment with mild acid or alkali;
(*c*) treatment with enzyme;
(*d*) autoclaving;
(*e*) germination;
(*f*) partial explosion;
(*g*) emulsification.

Protein Extraction

The original source of protein is the green plant cell and by processes of extraction and concentration we obtain the concentrated protein foods, egg, milk, meat and fish. In addition to these foodstuffs a large part of our protein requirement is met from cereals and pulses. The production of meat is a rather inefficient protein extraction process since the goat or sheep over its lifetime lay down not more than 10% of its protein intake as meat, milk production is more efficient and the overall efficiency of the average milking cow over its lifetime is of the order of 15–18%. The following table illustrates the uneconomic production of protein from animal source.

Source of protein	lb. per acre	lb. protein per acre
Wheat ..	640	78
Rice ..	738	50
Jowar ..	400	32
Bajra ..	320	28
Maize ..	800	48
Pulses ..	800	190
Groundnut ..	900	225
Soya-bean ..	900	360
Milk ..	3,700	90
Meat ..	390	54

From the above table it is evident that the production of protein in the oil-seeds like groundnut and soya-bean and pulses is economic from the agricultural aspect.

A Few Examples

The soya-bean is one of the richest known sources of protein among naturally occurring foods. Cooking has been shown to increase its nutritive value for rats, pigs, chicks, and other animals. This increase can be obtained

by autoclaving, partial explosion and emulsification as brought about in preparing milk. There is much evidence that man can satisfactorily digest and utilise the protein of soya-beans which have occupied a prominent place in the diet of the Orientals for centuries. Clinical observations show that infants can thrive for periods of more than a year with soya-bean milk as the sole source of protein in their diet. It has further been shown that the proteins of soya-bean flour are valuable supplements for correcting the amino-acid deficiencies of wheat flour. A mixture of 5 parts of soya-bean flour and 95 parts of wheat flour contains 19 per cent. more protein than wheat flour alone, and has twice its growth-promoting value.

Groundnut meal, after suitable processing, can be utilised for human consumption. Peanut flour appears less efficient than soya-bean flour in promoting growth in rats when each is given at a 9 per cent. level of protein, but definitely superior when given at a higher protein level (15 per cent.).

Wheat germ has long been recognised as a product nutritionally superior to whole wheat although attention has mainly been directed towards its high vitamin content. Recent studies on wheat germ show that it has a biological value equal to or superior to that of such animal proteins as skimmed milk, egg white and casein. Wheat germ and skimmed milk have also been shown to possess approximately equal power to improve the nutritive value of white flour and in this respect to be superior to soya-bean meal or groundnut meal. In the dog, skimmed milk powder and wheat germ are of approximately equal value in maintaining nitrogen balance. The scanty data on the amino acid contents of the proteins of wheat germ indicate that they compare favourably with such excellent proteins as milk and meat. From recent studies it appears that these processed vegetable proteins may be considered as essentially equivalent to first class animal proteins both when used as the sole source of protein or as protein supplements in the diet.

Wild Fodder Plants of Mysore

By K. Gopala Iyengar, M.Sc., and S. G. Narasimhachar, M.Sc.
Section of Economic Botany

Of the livestock in the world, about one-third is to be found in India. The fodder problem is of the same large magnitude, as the food problem for the teeming millions of the populace. By far, the bulk of forage is supplied by natural herbage and by the products of agriculture. Indian agriculture being essentially mixed farming, most food crops raised are of a dual nature providing both food and fodder. The area under fodder crops as such, is very small and bears no relation at all to the number of domestic animals that live on the land.

The availability and the volume of this forage, both natural and that from agriculture, is dependent on the vagaries of the monsoon. The bulky nature of fodders, moreover, does not lend itself for ready transport from areas of surplus, as in the case of foodgrains. Hence it is essential, that the major portion of the fodder should be made available on the spot or as near to it as possible. Thus it has become an age-long custom to supplement this ever-insufficient forage with loppings of various trees, common round about and acceptable to cattle.

Though Mysore is not so badly off in this respect than other parts of India like Punjab and Rajputana, the problem is a live one frequently becoming very serious. The following (see Table) is a list of plants other than grasses, commonly employed for purposes of forage during times of distress.

It is admitted that this lopped fodder is not liked to the same extent as grass or straw. The plants enumerated below are of varying degrees of palatability. Those that are more useful are recommended for being planted widely.

Some of the trees shed their leaves during summer, when they are most needed. In the interest of supplying adequate and useful fodder for the livestock, we feel, measures ought to be devised for the conservation of foliage of such trees before fall. Further, the process of the conversion of green leaves into hay or silage has to be investigated as in many cases the produce becomes more palatable after conversion than before. It would be of interest to investigate whether it is good to mix the loppings of several fodder trees to ascertain whether the blended product is more completely made use of. The possibilities of mixing the loppings as such or after conversion with grass or straw in varying proportions are worthy of investigation. Measures for collection and preservation of valuable fruits like those of *Atti* and Raintree for future use are problems which require experimentation.

Further, the effect of mixing the grounded seeds of Caroba bean, Horse tamarind, Mesquite, and *Jambu nerale* when dry and fed along with concentrates, has also to be investigated.

Our grateful acknowledgments are due to Dr. L. S. Dorasamy, M.Sc., Ph.D. (Lond.), Economic Botanist, for kind encouragement and Mr. B. P. Ramakrishnan, B.Sc., and Dr. K. Krishnaswamy Kadambi, D.Sc. (Münich), of the Forest Department, for many valuable suggestions.

No.	Name	Family	Kannada Name	Remarks
1	**Acacia arabica, Willd.** ..	Leguminosæ	Gobli, Kari Jali ..	The Babul or Gum Arabic is a small tree common throughout the maidan parts. The tender shoots and green pods are avidly consumed by cattle. This is a very valuable source of fodder, and as such is commended for fodder groves and plantations.
2	*A. catechu*, Willd. ..	,, ..	Kagli, Kachu ..	This small tree of maidan is less frequently found than Gobli. The tender shoots and flowers form a valuable fodder.
3	*A. ferruginea*, D. C. ..	,, ..	Banni ..	The Banni or Sami is also a small tree of maidan held in much reverence by Hindus. Though the tender shoots are consumed readily, the tree is rarely lopped.
4	*A. leucophlæa*, Willd. ..	,, ..	Bili Jali, Topal Toppale, Sarayi-bela ..	This tree is common in all parts of the State except Malnad. The leaves and young pods form valuable fodder. The pods should be fed sparingly, as animals exclusively fed on it frequently develop symptoms of distress.
5	*A. suma*, Buch. Ham. ..	,, ..	Mugali ..	A small tree frequent in Central and Eastern portions of Mysore usually confined to places with stagnant moisture, semi-dry tank beds and river banks subject to periodical inundations. The tender shoots are browsed by cattle.
6	*Achyranthes aspera*, L. ..	Amarantaceæ ..	Uttarani ..	A weed and a common herb of waste lands. Very sparingly browsed.
7	*Adina cordifolia*, Hook. ..	Rubiaceæ ..	Yettega, Arsinatega, Yethyaga	A lofty tree of the hill-forests and the adjoining maidan tracts, the leaves of which are fed to cattle.
8	*Aegle marmelos*, Correa. ..	Rutaceæ ..	Bilpatre ..	A tree sacred to Shiva and as such rarely lopped.
9	*Aerva tomentosa*, Forsk. ..	Amarantaceæ ..	.. ..	A common undershrub of plains, browsed by cattle.
10	*Ailanthus excelsa*, Roxb. ..	Simarubaceæ ..	Doddamara, Hemmara	A large ornamental tree of rapid growth, occurring sparsely in maidan and semi-malnad tracts. Leaves are fed to cattle.
11	*Albizzia amara*, Bow. ..	Leguminosæ ..	Sujjalu, Chujjalu	A medium-sized tree very common in dry forests except in the districts of Hassan, Tumkur and Chitaldrug. It is frequently lopped.
12	**A. lebbeck, Benth.** ..	,, ..	Bage, Hombage ..	The Siris is a large tree common all over and also planted along avenues. Cattle greedily feed upon the leaves. As this is a much esteemed fodder, it should be invariably planted in all fodder groves or plantations.
13	*A. marginata*, Merr. ..	,, ..	Hottebage, Kalbage	A large tree of the malnad, leaves of which may be fed to the cattle.
14	*Albizzia odoratissima*, Benth. ..	Leguminosæ ..	Bilvara ..	The raiyat's tree is fairly frequent in the western forests. The green shoots are nibbled.
15	*Alysicarpus rugosus*, D. C. ..	,, ..	.. ..	A tall annual of hills. Browsed when young.
16	*A. vaginalis*, D. C. ..	,, ..	.. ..	An annual of wastelands and a weed. Readily consumed by cattle.
17	*Amaranthus spinosus*, L. ..	Amarantaceæ ..	Mullu-dantu ..	A common weed and herb of dry wastes greedily consumed.
18	*Anogeissus latifolia*, Wall. ..	Combretaceæ ..	Dindiga, Bejjalu ..	A medium-sized tree common all over the semi-moist and dry zones, leaves of which are occasionally fed to cattle.
19	*Anthocephalus indicus*, A. Rich.	Rubiaceæ ..	Kadavala ..	The Kadamba is a very rare tree of malnad, occasionally lopped for fodder.

20	*Argyreia speciosa*, Sweet. ..	Convolvulaceæ.	Kallana-mele, Samudrapada, Kallana-hambu.	A small climber or straggler of dry wastes and scrubs, occasionally browsed by cattle.
21	*Artocarpus integrifolia*, L. ..	Moraceæ ..	Halasu ..	The jack tree is very commonly found and frequently planted along avenues. Young leaves are generally eaten by cattle.
22	*A. lakoocha*, Roxb. ..	,, ..	Vontemara ..	A large tree rarely found in malnads, leaves of which are relished by cattle.
23	**Balanities roxburghii, Planch.** ..	Zygophyllaceæ	Ingala, Ingalika ..	A small thorny tree of dry maidan, young twigs of which are relished by cattle. Is recommended for planting along the borders of fodder groves or plantations.
24	*Bassia latifolia*, Roxb. ..	Sapotaceæ ..	Kadu Ippe ..	The Mowa or Mahwa is occasionally met with in Mysore; while the flowers are relished, the leaves are only sparingly consumed.
25	*B. longifolia*, L. ..	,, ..	Ippe, Hippe ..	The South Indian Mahwa is common throughout maidan along avenues and in groves round about villages. The flowers are readily eaten but leaves sparingly consumed.
26	*Bauhinia purpurea*, L. ..	Leguminosæ ..	Kanchivala ..	A small tree of dry and semi-moist forests. Leaves are sparingly eaten.
27	*B. racemosa*, Lamk. ..	,, ..	Karacha, Bili-Kanchivala	A common tree of maidan and semi-malnad, leaves of which are consumed by buffaloes. A favourite food of elephants in dry weather.
28	*B. variegata*, L. ..	,, ..	Kempu-kanchivala	A large bush of dry scrubs often nibbled at.
29	*Bischofia javanica*, Bl. ..	Euphorbiaceæ ..	Gobranerale, Nilimara	A large tree sometimes found in Ghat forests, twigs of which are fed to buffaloes.
30	*Boerhavia diffusa*, L. ..	Nyctaginaceæ ..	Adakaputtinagida	The spreading hog-weed is very common and frequent in wastelands. This may be given to cattle in small quantities and is supposed to increase the yield of milk.
31	*Boswellia serrata*, Roxb. ..	Burseraceæ ..	Maddi, Dhupa ..	This is a medium-sized tree of maidan, young leaves of which are fed to buffaloes.
32	**Bridelia retusa, Spreng.** ..	Euphorbiaceæ ..	Gurige, Goje ..	A middle-sized tree generally found in the deciduous and mixed zones and on the outskirts of the ever-green belt. This provides a valuable fodder and is recommended for fodder groves or plantations in malnad and round about water holes in the maidan.
33	*Buchnania angustifolia*, Roxb. ..	Anacardiaceæ ..	Emme-murukulu, Maradi	A glabrous tree of hill regions; buffaloes eat the leaves.
34	*B. lanzan*, Spreng. ..	,, ..	Murkali ..	A tree of dry forests. Cattle browse upon the tender shoots.
35	*Butea frondosa*, Koen. ..	Leguminosæ ..	Muthuga ..	The Palas or Dhak, is very common in maidan. Leaves when fed to buffaloes are said to stimulate the flow of milk and increase its quantity.
36	*Cidrella toona*, Roxb. ..	Meliaceæ ..	Ganda-gariga Nandurike	The red cedar is a tall tree sometimes seen in malnad and Coorg. Cattle browse upon the green leaves and fruits when available.
37	*Celastrus paniculata*, Willd. ..	Celastraceæ ..	Kangondi, Karigonne, Ganganbe ..	A scandent shrub or climber of forests, often nibbled at.
38	*Ceratonia siliqua*, L. ..	Leguminosæ ..	.. ..	This is an introduced tree known as the Carob-bean, Locust-bean or St. John's bread. The pods constitute a very valuable stock feed.
39	*Clerodendron phlomoides*, L. ..	Verbenaceæ ..	Thaggi gida ..	A large rambling shrub of village hedges, consumed by buffaloes.
40	*Cocculus hirsutus*, Dieles. ..	Menispermaceæ	Dagadi ..	A climber of dry wastes and scrub jungles, browsed by cows and buffaloes.

No.	Name	Family	Kannada Name	Remarks
41	*Colebrookia oppositifolia*, Sm.	Labiatæ	..	A common shrub of hill-forests, readily browsed by cattle. Buffaloes are specially fond of it.
42	*Colocasia esculenta*, (L.) Scholt.	Araceæ	Kesavu	Tuberous herb, leaves of which are browsed by cattle.
43	*Combretum ovalifolium*, Roxb.	Combretaceæ	..	A large climbing shrub of maidan forests, young twigs of which are eaten by buffaloes.
44	*Cytisus proliferus*, L.	Leguminosæ	..	The tree-lucerne or Tagasaste is an introduced plant, the fodder value of which is highly acclaimed.
45	*Dalbergia latifolia*, Roxb.	,,	Beete, Biti	The South Indian black-wood or rose-wood is a large tree of malnad forests. Though frequently pollarded for fodder elsewhere, it is a reserve tree in Mysore.
46	**D. sissoo, Roxb.**	,,	Birate	The Sissoo is an introduced tree which is highly valued for its fodder. As such, it is recommended for fodder groves or plantations.
47	**Delonix elata, Gamble. Comb.**	,,	Sunkatti	The genus ***Delonix*** is more familiar as ***Poinciana.*** A small tree of Eastern Bangalore and Kolar, but never common. The foliage is readily consumed. The tree is recommended for fodder groves.
48	*D. regia*, Raff.	,,	Seeme Sunkesari	The Gul-mohar is an introduced tree, leaves of which are sparingly eaten in times of distress.
49	*Derris scandens*, Benth.	,,	..	A climber common in forests, the leaves and pods of which are readily consumed.
50	*Desmodium cephalotes*, Wall.	,,	..	A shrub of malnad and hill forests in the plains, browsed by cattle.
51	*D. diffusum*, D. C.	,,	..	A herb of dry wastes and scrubs, greedily fed upon by cattle.
52	*D. parvifolium*, D. C.	,,	..	A trailer of malnad hills, eaten by cattle.
53	*Desmodium pulehellum*, Benth.	Leguminosæ	..	A shrub of plain forests, browsed by cattle.
54	*D. trifolium*, D. C.	,,	Kadu avare balli	A trailer of dry wastes and a common weed of cultivation. Cattle are very fond of it.
55	*Dichrostachys cinerea*, W. and A.	,,	Badabakka, Waduwarada	A thorny shrub of dry places, leaves and pods of which are eaten by cattle.
56	*Digera arvensis*, Borsk.	Amarantaceæ	..	A herb of roadside and a common weed, browsed in times of scarcity.
57	*Dillenia pentagyna*, Roxb.	Dilleniaceæ	Kalthyaga, Kadukanigalu	A medium-sized tree of hill-forests. Buffaloes eat the young leaves and fruits.
58	*Diospyros melanoxylon*, Roxb.	Ebenaceæ	Mallali, Karimara	A medium-sized tree of hills and scrub forests, leaves of which are browsed by buffaloes.
59	*D. montana*, Roxb.	,,	Jagalaganti, Balagane	A small tree common all over, leaves of which are sparingly eaten by cattle, while buffaloes readily consume it.
60	*D. peregrina*, Gurke.	,,	Kusharata	A small tree of low-lying places in malnad, leaves of which are fed to buffaloes.
61	*Dodonea viscosa*, L.	Sapindaceæ	Bandari, Hangarike	A shrub of dry wastes, sparingly browsed in times of extreme scarcity.
62	*Dolichandrone falcata*, Seem.	Bignoniaceæ	Uddi, Wudige	A small tree of maidan and hill-forests, the tender leaves of which are fed to buffaloes.

63	*D. crispa*, Seem. ..	„ ..	Udi ..	A small tree of maidan and hill-forests, the tender leaves being fed to buffaloes.
64	*Ehretia laevis*, Roxb. ..	Boraginaceæ ..	Kapura, Hatippe..	A medium-sized tree of evergrreen zones. Leaves are used as fodder.
65	*Eichornia crassipes*, Solms. ..	Pontederiaceæ ..	.. ..	The water hyacinth is an introduced common aquatic herb which has become a serious pest ; may be fed in small quantities to cattle.
66	*Elaeagnus conferta*, Roxb. ..	Elæagnaceæ ..	.. ..	A common spiny shrub, the tender shoots of which are nibbled by cattle.
67	*Elaeodendron glaucum*, Pers. ..	Celastraceæ ..	Mukarive, Mukarthi Hakkeralu	A medium-sized tree of common occurrence. Cattle browse upon the tender leaves.
68	*Erioglossum rubiginosum*, Bl. ..	Sapindaceæ ..	.. ..	Small tree of hills in Kolar and Bangalore, leaves of which are fed to buffaloes.
69	*Eriolaena hookeriana*, W. & A...	Sterculiaceæ ..	.. ..	Small tree found on hills in maidan. Buffaloes eat the leaves.
70	*Ericibe paniculata*, Roxb. ..	Convolvulaceæ	.. ..	A large climbing shrub occasionally found in the hills of Kolar and Bangalore.
71	**Erythrina indica, Lam.** ..	Leguminosæ ..	Warjipe, Halivana	Common all over and often raised in gardens. Cattle are fond of the tender foliage and flowers. May be planted in fodder groves and plantations.
72	*E. suberosa*, Roxb. ..	„ ..	Mullumuttaga, Keechaka	A common tree of malnad, leaves of which are fed to buffaloes.
73	**Erythroxylum monogynum, Roxb.** ..	Erythroxylaceæ	Devadaru ..	The bastard sandal is a small tree or bush of the dry deciduous forests. Leaves are greedily consumed by cattle and the tree is recommended to be planted on the outskirts of groves and plantations.
74	*Feronia elephantum*, Correa. ..	Rutaceæ ..	Byala, Bela ..	The elephant or wood-apple is a medium-sized tree of the plains. Buffaloes eat the leaves.
75	*Ficus benghalensis*, L. ..	Moraceæ ..	Ala ..	The Banyan is a very common tree. Leaves are eaten by cattle.
76	**F. glomerata, Roxb.** ..	„ ..	Atti ..	The country fig is plentiful all over the maidan districts. In season the fruits form a very valuable stock feed and are greedily consumed. It is worthwhile making efforts to conserve and prepare the partially ripened fruits into a portable commodity. Highly commended for fodder groves and plantations.
77	*F. hispida*, L.f. ..	„ ..	Kadu atti ..	A small tree of moist localities. Leaves are relished by cattle.
78	*F. infectoria*, Roxb. ..	„ ..	Karibasari ..	A large spreading tree, leaves of which are rarely eaten by cattle.
79	*F. tsiela*, Roxb. ..	„ ..	Bilibasari ..	A large spreading tree leaves of which are rarely eaten by cattle.
80	*F. religiosa*, L. ..	„ ..	Arali, Aswatha ..	The sacred peepal is very common and held in reverence by Hindus. Cattle browse readily upon the tender leaves which are said to improve and increase the flow of milk. The use of this tree near habitations is naturally much restricted.
81	*F. Mysorensis*, Heyne. ..	„ ..	Goni ..	A large tree, leaves of which are sparingly eaten by buffaloes.
82	*F. roxburghii*, Wall. ..	„ ..	.. ..	This is an introduced plant, common in malnad and elsewhere in swampy places. Leaves are used as fodder.
83	**Flacourtia sepiaria, Roxb.** ..	Flacourtiaceæ ..	Miridi, Mindi ..	A rigid thorny bush of scrub jungles, the tender shoots of which are relished by cattle. May be planted in the borders of fodder groves or plantations.
84	*Flueggea leucopyrus*, Willd. ..	Euphorbiaceæ ..	Suli, Huli ..	A thorny shrub of scrub jungles, sparingly browsed by buffaloes.

No.	Name	Family	Kannada Name	Remarks
85	*F. microcarpa*, Blume.	Euphorbiaceæ	Bilisuli, Kore	A thorny shrub of scrub jungles, sparingly browsed by buffaloes.
86	*Garuga pinnata*, Roxb.	Burseraceæ	Halabage, Godda, Bolamatte	A large tree fairly common everywhere. The tender shoots are browsed by cattle.
87	*Gmelina arborea*, Roxb.	Verbenaceæ	Kooli, Sivane	A medium-sized tree of common occurrence. Cattle eat the fruits.
88	*Grewia emarginata*, W. & A.	Tiliaceæ	.. ..	A shrub of reserved forests in plains, browsed by cattle.
89	*G. flavescens*, Juss.	,,	.. ..	A small tree of reserved forests, leaves of which are relished by most cattle.
90	*G. oppositifolia*, Roxb.	,,	Butale	A common tree in open forests of malnad. Sheep browse on tender foliage.
91	*G. orientalis*, L.	,,	Karaki	A climbing shrub of scrub jungles. Tender shoots are eaten by cattle.
92	*G. tiliaefolia*, Vahl.	,,	Tadasalu Tadasal	A medium to large tree fairly common in malnad. Sheep browse on the tender shoots.
93	**Guazuma tomentosa, Kunth.**	Sterculiaceæ	Rudrakshi	The bastard cedar is an introduced tree, the leaves and fruits of which are highly relished by cattle. Recommended for fodder groves or plantations.
94	*Gymnosporia montana*, Roxb.	Celastraceæ	Tandarsi Tanasimele	A big shrub exceedingly common in the dry deciduous forests of all districts. When softened by beating, the leaves become useful as a green food for cattle.
95	*Hamiltonia suaveolens*, Roxb.	Rubiaceæ	.. ..	A large shurb of dry scrub forests, browsed by cattle in times of great scarcity.
96	**Hardwickia binata, Roxb.**	Leguminosæ	Karachi, Yennemara	The kamara is a deciduous tree of maidan forests, generally confined to Chitaldrug, Tumkur and Bangalore. This tree provides a very valuable fodder and should be planted in forage groves or plantations.
97	*Helicteres isora*, L.	Sterculiaceæ	Kowri, Yedamuri, Kavargi	The country screw tree is a shrub of mixed deciduous and dry forests. Buffaloes eat the young leaves occasionally.
98	*Heterophragma roxburghii*, D.C.	Bignoniaceæ	.. ..	A rare tree of malnad. Leaves are fed to cattle.
99	*Heylandia latibrosa*, D.C.	Leguminosæ	Godhadi	A common spreading annual and also a weed of cultivation. Buffaloes are very fond of it.
100	*Hibiscus lampas*, Vav.	Malvaceæ	..	A common under-shrub of forests, young leaves of which are relished by buffaloes. Is sometimes known as *Thespesia lampas*.
101	*Hiptage medablota*, Gaertn.	Malpighiaceæ	Adaraganchihambu	Madhavilata is a large woody climber generally found in forests ; the tender shoots are sometimes browsed by cattle.
102	*Holoptelea integrifolia*, Planch	Ulmaceæ	Thapsi, Rasbija, Kaladri.	The common entire leaved elm is a large tree. The young shoots are greedily eaten by cattle although the smell is offensive.
103	*Holostemma annulare*, K. Schum.	Ascelpiadaceæ	Jeevahale balli	A twiner of waste scrubs and hedges, browsed by cattle.
104	*Hymenodictyon excelsum*, Wall.	Rubiaceæ	Doddathoppe, Doddimara	A medium-sized tree of open malnad. Leaves are occasionally fed to cattle.
105	*Indigofera cardifolia*, Heyne.	Leguminosæ	.. ..	A very common herb, greedily eaten by buffaloes.
106	*I. enneaphylla*, L.	,,	Kenneggilu	A small herb of waste places browsed by buffaloes and sheep.
107	**I. glandulosa, Willd.**	,,	.. ..	A very common herb of Kolar and Bangalore relished by cattle and advocated for groves and plantations.
108	*I. linifolia*, Retz.	,,	.. ..	A herb of dry wastes very common on black cotton soils, browsed sparingly.
109	*I. oblongifolia*, Forsk.	,,	.. ..	A shrub of waste lands and maidan, browsed by cattle.

110	*Ipomoea sepiaria*, Koen. ..	Convolvulaceæ	..	A twiner of maidan, frequent in hedges and near tanks. Provides a useful cattle fodder and is supposed to increase the flow of milk.
111	*Kydia calycina*, Roxb. ..	Malvaceæ ..	Bendemara ..	A small tree of the mixed deciduous zone forests all over the State. Leaves are fed to buffaloes.
112	*Lagerstroemia parviflora*, Roxb.	Lythraceæ ..	Chennangi ..	A medium to small tree of the maidan and semi-malnad parts. Buffaloes eat the leaves sparingly.
113	**Leucaena glauca, Benth.** ..	Leguminosæ ..	.. ..	The white Popinac or horse tamarind, is an introduced shrub or small tree with a high reputation as stock feed. In addition to the leaves, the seeds are also fed to cattle after being crushed or boiled. May be grown in fodder groves or plantations.
114	*Limnanthemum cristamum*, Griseb.	Gentianaceæ ..	.. ..	A common aquatic herb sometimes employed for feeding cattle.
115	*Litsea chinensis*, Lamk. ..	Lauraceæ ..	.. ..	A medium-sized tree of malnad, young leaves of which are rarely fed to buffaloes.
116	*Mallotus philippinensis*, M. Arg.	Euphorbiaceæ ..	Kapilarangu, Kumkuma mara, Hulichendu	The Kamala-dye tree is a small tree of the malnad and maidan. Leaves are fed to buffaloes.
117	*Mangifera indica*, L. ..	Anacardiaceæ ..	Mavu ..	The mango is a very common tree. The tender leaves are sparingly eaten by cattle.
118	*Melia azedarach*, L. ..	Meliaceæ ..	Hutchubevu, Chikkabevu	The Persian lilac or bead tree is common round towns and villages of maidan. Leaves provide good forage for sheep and goats but sparingly eaten by cattle. To be planted in groves where sheep and goats are reared.
119	*M. azadirachta*, L. ..	,, ..	Bevu ..	The leaves of the neem tree are sparingly eaten by cattle. This often leaves a bitter flavour in the milk.
120	*Michelia champaka*, L. ..	Magnoliaceæ ..	Sampige ..	The Champak is a very common tree, leaves of which are relished by cattle.
121	*Mimusops hexandra*, Roxb. ..	Sapotaceæ ..	Ranja, Bakula	A large tree of ghat forests. Buffaloes eat the leaves sparingly.
122	**Mitragyna parviflora, Korth.** ..	Rubiaceæ ..	Kadagada, Kadavala Kadani, Kongu	A common tree, the leaves of which provide a useful fodder. May be planted in fodder groves or plantations.
123	*Moringa oleifera*, Lamk. ..	Moringaceæ ..	Nugge	The drum-stick or horse radish is a very common tree. Its leaves and flowers are sparingly eaten.
124	*Morus indica*, L. ..	Moraceæ ..	Uppunerale	A deciduous tree both wild and cultivated (for silkworm rearing) but cultivated usually as a shrub. Leaves are said to be a good fodder for cattle.
125	*Ochna squarrosa*, L. ..	Ochnaceæ ..	Mudali, Narole	A shrub of common occurrence, very rarely browsed by cattle.
126	**Odina wodier, Roxb.** ..	Anacardiaceæ	Udi. Panal. .. Gogal, Godda	A large tree of maidan. Cattle feed voraciously on the green leaves. Recommended for fodder groves or plantations.
127	*Opuntia dillenii*, Haw. ..	Cactaceæ ..	Papaskalli, Nagadali	The common prickly pear, an American plant, naturalised in India, the so-called leaves of which have a good fodder value after the spines are removed.
128	*Orobanche cernua*, Loefl. ..	Orobanchaceæ	Benkigida ..	A parasite of cultivation sometimes used as a cattle feed. Though cattle may be averse to eat at first, in time they become accustomed to it and are supposed to yield more milk. It is however advisable not to feed this to cattle as the seeds of the parasite get disseminated in the manure.
129	*Ougeinia dalbergioides*, Benth. ..	Leguminosæ ..	Kalhonne, Karihonne	A medium-sized tree of malnad forests. Branches are often lopped as cattle feed.

No.	Name	Family	Kannada Name	Remarks
130	*Oxystelma esculentum*, R.Br.	Asclepiadaceæ	..	A climber of maidan wastes browsed by cattle.
131	*Pavetta indica*, L.	Rubiaceæ	Pavate, Pappadi	A shrub of dry wastes and scrubs rarely browsed by cattle.
132	*Phoenix sylvestris*, Roxb.	Palmeæ	Eechalumara	A medium-sized palm, tender leaves of which are eaten in times of distress.
133	*P. humilis*	,,	Kirichalu	A small palm, tender leaves of which are eaten in times of distress. (This is a smaller palm than the above, and by many is included under *P. sylvestris*, Roxb.)
134	*Phyllanthus emblica*, L.	Euphorbiaceæ	Nelli	The Indian gooseberry or *Emblic-myrobalan* is a very common medium-sized tree. Buffaloes eat the leaves and fruits.
135	*P. maderaspatensis*, L.	,,	Nelanelli	A small shrub of maidan wastes browsed by cattle.
136	Pithecolobium **dulce, Benth.**	Leguminosæ	Seeme hunse, Kadu hunse kayi	The Manilla-tamarind is a very common tree but not a native. Its leaves and fruits are greedily eaten by cattle. May be planted along the borders of groves and plantations.
137	**P. saman, Benth.**	,,	..	The rain-tree is an introduction to the State and is common as an ornamental The leaves are sparingly eaten by cattle, but the fruits provide a nutritious food. May be planted in groves and plantations and methods devised to collect and preserve the pods in a palatable condition.
138	*Polyalthia suberosa*, Hook. f. & T.	Anonaceæ	..	A small tree of malnad, leaves of which are fed to buffaloes.
139	*Polygonum chinense*, L.	Polygonaceæ	Nelakumbala	A common undershrub of forests exceedingly relished by cattle.
140	*Pongamia glabra*, Vent.	Leguminosæ	Honge	The Indian beech is a very common tree. Leaves are fed to cattle.
141	**Prosopis chilensis, Stuntz.**	,,	..	The honey locust or Mesquite is an introduced tree having much in common with Acacias. The flowers and pods provide a valuable feed for stock. This species is familiarly known as *P. juliflora* and should be planted in groves and plantations.
142	*Psoralea corylifolia*, L.	,,	Bavanchi	A common weed of cultivation very sparingly eaten on account of its offensive smell.
143	**Pterocarpus marsupium, Roxb.**	,,	Honne	The Indian kino is a large tree occurring all over the State. Its leaves provide a useful feed, recommended for fodder groves or plantations. But the tree happens to be a reserved one.
144	*Putranjiva roxburghii*, Wall.	Euphorbiaceæ	Putranjivi, Putrajivi	A medium-sized tree of malnad largely found along the river banks. Leaves are used as fodder.
145	**Randia dumetorum, Lamk.**	Rubiaceæ	Mangare	A common thorny shrub found all over the State except in the ever-green zone, tender shoots of which are relished by cattle. Recommended for the borders of groves and plantations.
146	*R. uliginosa*, D.C.	,,	Doddakare, Bonugare	A small tree of malnad confined to ill-drained patches of forest. Leaves are fed to cattle.
147	*Rhyncosia minima*, D.C.	Leguminosæ	..	A twiner of maidan wastes eaten by cattle.
148	**Salix tetrasperma, Roxb.**	Salicaceæ	Niranje, Niravanji	The South Indian willow is a small tree of river banks and very wet places. The green foliage is a valuable cattle feed and the tree is recommended for fodder groves in swampy situations.

149	*Schleichera trijuga*, Willd.	Sapindaceæ	Sagade, Kendala	The Ceylon oak is a large tree of the malnads, ghats and other forests all over the State. Young leaves and fruits are eaten by cattle.
150	*Sesbania aegyptica*, Pers.	Leguminosæ	Jinangi	A small shrub or tree of wet places very much in cultivation. Cattle do not relish the foliage at first but get accustomed to it in due course. Sheep and goats are very fond of it.
151	**S. grandiflora, Pers.**	„	Agase	A very common tree. Leaves and flowers are very much relished by cattle. Recommended for fodder groves or plantations.
152	*Smithia sensitiva*, Ait.	„	..	A weed of malnads greedily eaten by cattle.
153	*Sonchus oleraceus*, L.	Compositæ	..	A common milky herb greedily eaten by cattle.
154	*Spondias mangifera*, Willd.	Anacardiaceæ	Amate, Goddamate	The hog-plum is a very common tree. Leaves are fed to cattle.
155	**Streblus asper, Lour.**	Moraceæ	Mitli	A small tree of general occurrence. Cattle eat the leaves and the tree is recommended for fodder groves and plantations.
156	*Syzygium jambolana*, D.C.	Myrtaceæ	Nerale, Jambunerale	The genus *Syzygium* is otherwise familiar as *Eugenia*. The Indian black plum is a common tree and is very frequent along avenues. Leaves are sparingly eaten but the fruits are highly relished.
157	*Tamarindus indica*, L.	Leguminosæ	Hunase	The Tamarind is a very common tree, tender shoots of which are fed to cattle.
158	*Tephrosia purpurea*, Pers.	„	Vajraneeli	A common, herbaceous perennial; fair fodder before flowering.
159	*Terminalia arjuna*, W. & A.	Combretaceæ	Bilimatti, Toramatti	A large tree of maidan and malnad generally confined to river banks. Tender shoots are eaten by buffaloes, but the tree is a reserved one.
160	*T. belerica*, Roxb.	„	Tare	The *Beleric-myrobalan* is a large tree common throughout. The fruits are greedily eaten by cattle. In Northern India, the leaves are considered to be very good for milch cows.
161	*T. chebula*, Retz.	„	Alale	The Chebulic or black myrobalan is a common tree of maidan forests. Tender shoots are eaten by buffaloes.
162	*Thespesia populnea*, Cav.	Malvaceæ	Huvarasi	The Portia tree is commonly planted all over the State. Leaves are sparingly eaten by cattle.
163	*Tiliacora acuminata*, Miers.	Menispermaceæ	..	A common climbing shrub of hedges and wastes, fed upon by buffaloes.
164	*Tinospora cordifolia*, Miers.	„	Amruthaballi	A common twiner browsed by cattle.
165	*Trewia nudiflora*, L.	Euphorbiaceæ	Kadukumbala	A large tree of river banks in malnads. Buffaloes feed on the leaves.
166	*Tridax procumbens*, L.	Compositæ	Gabbugida	A weed of cultivation and herb of wastes and pastures, relished by cattle.
167	*Turpinia nepalensis*, Wall.	Staphyleaceæ	Nila	This is also known as *T. pomifera*. A large tree of ghat forests, leaves of which are fed to buffaloes.
168	*Vangueria spinosa*, Roxb.	Rubiaceæ	..	A thorny shrub of dry wastes browsed by cattle.
169	*Ventilago calyculata*, Tulsane.	Rhamnaceæ	..	A climbing shrub of dry wastes eaten by buffaloes.
170	*V. maderaspatna*, Gaertn.	„	Popli	A scandent shrub common in maidan and semi-malnad. Browsed by buffaloes.
171	*Vicoa indica*, D.C.	Compositæ	..	A common weed and a herb of wastes, highly relished by buffaloes.
172	*Vitex leucoseylon*, Linn.f.	Verbenaceæ	Holelakkimara	A small tree of malnad and semi-malnad. Buffaloes eat the leaves.
173	*Wendlandia exerta*, D.C.	Rubiaceæ	Kanusuragi	A small tree found all over the State, leaves of which are sparingly eaten in times of distress.
174	*Woodfordia fruticosa*, Kurz.	Lythraceæ	..	A shrub of hills and scrub forests, browsed by buffaloes.

No.	Name	Family	Kannada Name	Remarks
175	*Wrightia tinctoria*, R. Br. ..	Apocynaceæ ..	Hale, Beppale ..	A common small tree of maidan and semi-malnad forests, leaves are eaten by buffaloes.
176	*W. tomentosa*, R. & S. ..	„ ..	.. ..	A small tree of common occurrence in maidan. Leaves are eaten by buffaloes.
177	*Xylia xylocarpa*, Taub. ..	Leguminosæ ..	Jambe ..	The Irul tree is a large tree of malnad forests. Young leaves are fed to cattle especially buffaloes.
178	**Zyzyphus jujuba, Lamk.** ..	Rhamnaceæ ..	Yelachi, Bore ..	The jujube tree is found all over the maidan districts and cattle are fond of the tender shoots and fruits. Recommended for fodder groves or plantations.
179	*Zizyphus nummularia* W. & A.	Rhamnaceæ ..	Purpalli, Paragi ..	A climbing thorny shrub of dry scrub and fences around villages; browsed by sheep and goats.
180	*Z. rugosus*, Lamk. ..	„ ..	Bemmaralu, Sannaguraki	A thorny climber of malnad browsed by cattle.
181	*Z. xylopyra*, Willd. ..	„ ..	Chatte, Gotti ..	A small tree of scrub forests in maidan and semi-malnad. The young shoots and fruits are sometimes eaten by cattle.

Recent Studies on " Inert " Dust Treatment of Foodgrains*

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The use of certain inert bases like silica, lime, clays, etc., as diluents for toxic chemicals such as the arsenicals employed as insecticides in agricultural practice is quite well known. The action of these " inert " bases depends largely on their particle size and often on their colloidal character for effecting a good adhesion of the insecticidal chemicals. These diluents are non-reactive by themselves and hence the term " inert " dusts. Where such special adhesion is lacking in the diluent, one must look for it in the physical property of the particles. Thus, the finer the particle, the greater is its adhesion to a surface. In order to produce such fine particles, it is appropriate to fractionate a powder by screening it generally through a 325-mesh screen, whereby 95% of the dust passes through it. This is the finest mesh that is mechanically possible, the fineness of the particle then being anything below 45 μ.

It was discovered as early as 1927 in Germany that some of these diluents, particularly magnesia and silica, brought about the mortality of grain weevils behaving thus as insecticides. It will at once be apparent that the expression " inert " dust is in the nature of a contradiction of terms. For want of a better terminology, this expression has obtained a wide currency. The term " Mineral " dust would seem somewhat more appropriate. The control of grain infestation by different dusts was attributed by Zacher (1927) to their desiccating effect on the weevils invading the grains. Simultaneously, a proprietary product called "Naaki" was on the market and proved effective in controlling grain infestation. " Neosyl " is another proprietary product containing precipitated silica. Being very fine, its effect on weevils was remarkable. Considerable quantities of grain exported to the Far East appeared to have been treated with this product. The use of lime and very fine earths has been in vogue in this country from very early days. Chiu (1939) employed crystalline silica in controlling the bean weevil and correlated the toxicity of the chemical with the fineness of the particles. No other harmful effects of these dusts were observed on the insects. Since the dust particles kill the insects by a process of desiccation, it appears natural to expect that the same would be most effective at low humidities and in a very fine state of division. The dusts have been found to act on diverse insects and in their different stages. It must at once be indicated here that this process of treating the grains is more in the nature of a protective treatment rather than a curative one which is the case with fumigation.

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The dusts have no action on the alimentary system nor do they cause any untoward effect on the digestive system. The treatment of grains with dusts can therefore be readily adopted to protect the same from insect infestation.

The actual treatment of foodgrains by insecticidal dusts is governed by three factors. In the first place, the condition of the grain prior to storage is of great importance. The moisture content of grains is a factor which determines largely the possibility of insect attack and subsequent mold growth. The safe limit for moisture content has been fixed at 12–14 per cent. at which insects would not normally invade and develop in foodgrains when properly stored. But it is not adequately realised that the condition of the atmosphere in which such grains are stored are of equal, if not greater importance. It may be remarked here that dry grains will not remain as such in a humid atmosphere and *vice versa*. In other words, grains come readily into equilibrium with the moisture content of the air. It is therefore of the greatest importance that grains which may be treated to the safe limit of moisture content and consequently to a state of freedom from infestation, must be stored in such a way that they are not exposed to atmospheric changes. This protection for grains from exposure to humidity changes can only be ensured in well-sealed containers, be they bins, granaries or other suitable masonry structures. It will at once be apparent that the method of storing grains in gunny bags in godowns as is current in different parts of the country is wholly unsatisfactory. The different governments would therefore be well advised to alter their methods whereby the loss of grains from damage or insect attack during storage is reduced to the barest minimum.

If properly carried out, this procedure affords a very good means of storage. Unfortunately, the observance in practice leaves much to be desired. Primarily, there is no guarantee that the grain as purchased at the source is free from infestation. Again during transit by rail, cart or in ships, the chances of such infestation are so large that there can be no adequate control against insects unless radical changes are introduced by the authorities and enforced rigidly. Thirdly, prior to introduction into stores, the grain has to be thoroughly examined for insect population and processed according to needs. The source of infestation is so wide as well as the variety of insects is also large.

Secondly, the type of insects and the different stages of those infesting foodgrains must be separately considered. It is not proposed to deal with the entomological aspects of this question here, except in relation to the action of different dusts on the different insects in their different stages.

Lastly, the physico-chemical factors in relation to mortality of insects through " inert " dusts will be examined in detail. In speaking of the raw materials necessary for this purpose, it may be stated here that the main feature of the dusts is their abrasive action on the cuticle of the insect, in consequence of which the fatty layer is removed leading to the evaporation of water from the body surface *via* such abraded parts. Hence it is essential

that the material selected must be hard in character and not soft like kaolin. In practice, such material must have a hardness above 6, in the Moh's scale. A number of substances is thus available, *e.g.*, felspar, quartz, carborundum, magnesite, dolomite, silica. The only exception has been featured in the gas mask charcoal, which is highly reactive against insects. No direct correlation has yet been discovered between chemical constitution and insecticidal action of these dusts.

In considering the action of such materials on insects in stored products, attention must be paid to the quality of the dust. It is well known that coating grains with a dust is very satisfactory when it is fine. The coarser particles do not possess adhesive properties as indicated earlier. It may not be well known that the finest particles of the minerals mentioned above have been shown to effect insect mortality in stored grains. It is presumed that these fine particles retain their microcrystalline structure and cause the abrasion on the cuticle of the insects. It is not proposed to discuss here the method of preparing such fine dusts except to state that certain considerations are involved in producing a useful dust which can be rendered useless by changing the method of manufacture. The influence of particle size on insect mortality is shown below:

Per cent. distribution of particle size and insect mortality

Dust	Range of particles in microns						
	>56	56–40	40–28	28–20	20–14	14–10	<10
Magnesite ..	4·5	3·1	4·8	3·6	5·1	4·2	79·7
Neosyl ..	1·1	0·25	0·2	0·25	0·3	0·8	97·1
	Percentage insect mortality						
Magnesite ..	4	6	10	38	46	58	94
Dolomite ..	4	14	14	26	28	44	88

The distribution of particle size in "Neosyl" is worth noting, particularly the particles under 10 μ.

Influence of size of carborundum particles on insects

(20 insects were tested in dishes)

Range of particles in microns	Insect mortality in per cent.			Per cent. kill in wheat in 4 days
	1 day	2 days	3 days	
1–4	20	90	100	63
1–10	5	85	100	29
5–20	15	85	100	9
2–4	15	85	100	97
Above 15	0	0	20	..
Control	0	0	5	0

In their studies Briscoe, *et al.* (1944) secured a distribution of 92% of the particles in the carborundum powder under 9 μ. It is therefore no surprise that this powder is so reactive. In a highly reactive dust processed from a clinker by the writer, the particle size distribution is almost similar to Neosyl.

It has been shown that only finely ground dusts must be used for protective coating of grains. Coarser particles are of no value. The conditions under which these fine dusts retain their high activity are also the same under which grains keep dry. In other words, the humidity of the atmosphere influences the treatment with dusts as it does the grains. The method of storage is thus the most vital point in this procedure. It is to be presumed that the coated grains are stored free from atmospheric changes. The effect of R. H. has been stressed by several investigators. In fact, the high figures for insect mortality are due to this fact in all their experiments. The rate of loss of weight of *C. granaria* (granary weevil) under different R.H.'s on treatment with Neosyl has been investigated by Briscoe (1943). In another study, Briscoe, *et al.* (1944) followed the loss in weight of weevils, dead and dusted, in relation to time. The similarity of the rate of loss is striking and lends support to the desiccation view. Germar (1936) studied the influence of humidity in relation to time to cause 100 per cent. mortality of insects in grains dusted with silica. In Australia, Fitzgerald (1945) brought out significantly this fact which is reproduced below:

Effect of dusts in relation to humidity

T = 26° C. Figures represent mortality per cent. of *C. granaria*

Dust	Relative humidity		
	40%	60%	75%
Magnesite	100	98	76
Dolomite	100	92	46
Control	6	14	6

The dosage of a given dust for grain treatment is a feature which must be more closely examined. It has always been assumed that dust employed at 1 per cent. on the weight of grain is more than appropriate. It has been ascertained by Fitzgerald in Australia that this quantity could be safely reduced to a quarter. A lower percentage, say 0·1%, has not been found quite effective, as can be seen from the following table.

It must however be mentioned here that the per cent. distribution of particles in magnesite under 10 μ is lower than in Neosyl. Therefore if a lower percentage of the dust is to be used, the dust particle must be very fine. In coating the grains with a dust, two methods are possible. The material under consideration may be ground to pass through say 250 mesh sieve in the hope that an adequate percentage of the finest particles would be present in the fraction selected. In this case, the quantity of dust actually

Dosage of dust in relation to insect (C. granaria) *mortality in treated wheat*

T : 26° C. R. H. = 60%

Dust	Weight of dust in per cent.			
	1·0	0·5	0·25	0·1
Control	Nil	Nil	Nil	Nil
Magnesite	94	92	90	32
Neosyl	100	100	98	82

employed may have to exceed 1% if satisfactory results are to be secured. There is bound to be waste in dust due to defective or poor adhesion of particles over 20 μ. In the second process, the material is ground in a suitable equipment and if necessary, under frequent testing, for determining the distribution of particles below 15 or 10 μ. When the required percentage is secured, it may be processed so as to keep it dry and in a fine state of division. In this way, the writer has secured a dust which has good adhesion even under 0·2% with satisfactory results. It has also been observed that very fine particles less than 2 μ form easily small lumps and in consequence present some difficulties. A distribution of particles anywhere below 10 μ seems more than adequate.

A systematic study of dust insecticides on stored grains has revealed the efficacy of certain substances on insects of different types and in their different stages. In order that these results could be relied upon for large-scale operations, the course of breeding of insects during storage, particularly in dust-treated wheat has been investigated with encouraging results. Such dusts are found to be effective on adults and the larvæ. The problem of their eggs is then no problem at all, since the larvæ emerging from them are immediately exposed to the dusts and killed. With the death of adult insects, egglaying ceases. The solution to the problem of storing grains free from infestation is thus satisfactory through protective coating with such insecticidal dusts.

Effect of dusts on the mortality of adult insects

(Expressed in per cent.)

Dust	Calandria			Tribolium			
	Days			Days			
	1	2	3	1	2	3	4
Neosyl	5	65	100	5	65	95	100
Corborundum	0	70	100	25	80	95	100
Act. Carbon	5	85	100	95	100	..	..
Alumina	5	75	100	100	..	..	..

Similar results have been secured with other insect species.

Effect of dust on insect larvæ (Mortality expressed in percentage)

Dust	Tribolium					Mealworm				
	1	2	4	5	7	1	3	5	7	8 days
Neosyl ..	50	60	100	..	..	90	100	..	..	..
Carborundum ..	20	50	60	70	70	0	10	10	10	10
Alumina ..	100	..	..	..	..	90	100	..	..	..
Control ..	10	10	20	20	40	..	..	..	..	..
R. H. ..	80%					0%				

In all these trials, the dosage of the dust was at the rate of 1 per cent. on the weight of grains. In the following, the influence of different quantities of dust on insect breeding is reported.

Effect of dust on insect breeding during storage

Dust	Dust Concentration											
	0·5 per cent.				0·25 per cent.				0·1 per cent.			
	C		R		C		R		C		R	
	No.	Mortality %	No.	Mort. %	No.	Mort. %	No.	Mort. %	No.	Mort. %	No.	Mort. %
Neosyl ..	335	98	300	100	370	96	290	100	1210	41	760	40
Magnesite ...	455	96	1100	45	860	63	1020	31	2210	16	2650	43
Dolomite ..	680	78	690	82	1740	24	1150	30	3810	11	1900	12
Control ..	6070	25	4080	4	..	..	..	..	..	..	..	..

C—*Calandria granaria* R—*Rhizopertha*
T : 26° C., R. H. 60% T : 32° C., R. H. 60%

Neosyl even at a concentration of 0·25% by weight has been found to inhibit insect multiplication to a considerable extent, while many others act at higher concentrations. (The difference in particle size between these has been indicated above and accounts for this discrepancy in action.)

In the end, the results of an experiment reported by Fitzgerald on the protection afforded to grains through application of dusts and reproduced below, bear ample evidence of their usefulness in practice.

A critical examination of the data obtained by Fitzgerald clearly shows the superiority of " Neosyl " as an effective insecticidal dust, even at a fairly low concentration, such as 0·25%. In practice, its adoption is limited, because of the hazard to persons exposed to it. It is well known that silicosis is induced by the finest particles of silica in the free and uncombined state. Such dusts are generated during granite cutting, in mining operations, and in foundry practice. According to Fairhall (1945) silicosis is caused *by free silica and not by silica in the combined state such as silicates.* It is

Protecting grains through coating with dusts

Dust	Concentration %	*C. granaria*			*R. rhizopertha*			
		Insect		Wheat in grams	Insect		Wheat in grams	Floury Frass in grams
		No.	% Dead		No.	% Dead		
Neosyl ..	0·5	335	98·5	375	300	100	410	2
	0·25	370	97·5	373	290	100	377	1
	0·10	1210	91·0	314	260	40	350	18
Dolomite ..	0·5	660	78	361	690	82	373	7
	0·25	1740	24	326	1150	30	352	24
	0·10	3800	11	268	1900	12	315	53
Magnesite ..	0·5	435	95·9	366	1100	45	358	21
	0·25	870	63·0	348	1000	31	352	23
	0·10	2200	16·0	314	2600	43	299	69
Original ..	..	300	0	400	300	0	400	0
Control 1 ..	..	7300	4	185	4900	3	180	145
2 ..	..	4800	58	221	3300	6	250	92

therefore not safe to recommend this substance despite its potency against insects in stored foodgrains. A cheap substitute in the form of scorched paddy husk has been reported by Narasimhan and Krishnamurthy (1944) from the Department of Agriculture in Mysore. According to them, the burnt husk is passed through 100 mesh and the resulting material has been reported to be highly active in killing insects. It must be pointed out that such a material contains as much as 95% silica in the *free* state—a figure which closely agrees with that of quartz. Hence its adoption is fraught with equal danger. Again, the screening through 100 mesh may not result in a fine powder which is so necessary for a successful treatment by this method.

In the course of some investigation on the storage of maize for the starch industry, the writer had to study the action of some kinds of dust for preservative purposes. Waste products of industries offer the cheapest raw materials. One such material from sugar factories has been shown by the writer to be very effective in controlling insect development in stored grains. Details of this investigation will be reported elsewhere.

In summarising the researches on "inert" dusts as insecticides against pests of stored foodgrains, it must be pointed out that such dusts must be in a very fine state of division and be capable of good adhesion to the grains. The treated grains should be kept in special containers so as to avoid exposure to humidity changes of the atmosphere. While silica in the fine state has been found to be very effective in destroying insects in all stages, the industrial hazard to persons exposed to this dust militates against its adoption. Active search for a cheap and effective substitute was made by the writer with success. A proprietary product is now available for use.

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